Recent Research in Science and Technology 2010, 2(5): 45-52
ISSN: 2076-5061
www.recent-science.com

BOTANY

BIOFERTILIZING EFFICIENCY OF BROWN AND GREEN ALGAE ON GROWTH, BIOCHEMICAL AND YIELD PARAMETERS OF *CYAMOPSIS TETRAGONOLABA* (L.) TAUB.

S. Sivasangari Ramya[1], S. Nagaraj [2] and N. Vijayanand[1*]

[1]Department of Botany, Arumugam Pillai Seethai Ammal College, Tiruppattur, Affiliated to Alagappa University, India
[2]Centre for Advanced Studies in Botany, Madras University, Chennai, India

Abstract

The effect of liquid extracts of marine algae *Sargassum wightii* and *Ulva lactuca* when applied as soil drench to cluster bean plant increased the growth, biochemical and yield of the plant. Liquid extracts of *Sargassum wightii* (1.5%) and *Ulva lactuca* (1.0%) was found to have maximum influence on growth parameters viz., shoot length, root length, total fresh and dry weight, leaf area and moisture content. Further, there was a significant increase in biochemical parameters such as photosynthetic pigments, protein content, amino acids, reducing sugar, ascorbic acid, nitrate reductase activity. Similarly, enhancement in yield parameters such as number of pods per plant, pod weight, pod length and number of seeds per pod were also observed. Higher concentrations of both algal extracts were found to show inhibitive effect on all above parameters studied.

Keywords: Seaweed extract; *Sargassum wightii*; *Ulva lactuca*; growth; biochemical; yield; cluster bean

Introduction

Chemical agriculture has made an adverse impact on the health care of not only soil but also the beneficial soil microbes. In present scenario, chemical fertilizers have degraded the fertility of soil making it acidic and rendering it unsuitable for raising crop plants. Soil fertility is diminishing gradually due to soil erosions, loss of nutrient, accumulation of salts and other toxic elements and un-balanced nutrient compensation. Organic wastes and bio-fertilizers are some of the alternate sources to meet the nutrient requirement of crops. Seaweeds, one of the important marine living resources are now a days considered as a promising marine bioresource. They are available largely in shallow coastal waters of sea, estuaries and backwaters. Seaweed fertilizer was found to be superior to chemical fertilizer because of high level of organic matter aids in retaining moisture and minerals in upper soil level available to roots (Wallenkemp, 1955). Exogenous application of seaweed extracts have been observed to increase the yield and productivity of crop plants, but the mechanisms for such responses remain argely unknown (Featonby-Smith and Van Staden, 1983). Earlier studies have reported positive effects of seaweed extracts on root growth when applied to the rhizosphere or as a foliar spray (Blunden et al., 1977; Featonby Smith and Van Staden, 1987). Chemical analysis of seaweeds and their extracts have revealed the presence of a wide variety of plant growth regulators such as auxins and cytokinins in varying amounts (Taylor and Wilkinson, 1977; Jameson, 1993; Zhang and Ervin, 2004). Moreover, application of marine macro algae in modern agriculture has been reported by Zodape 2009; Jothinayagi and Anbazhagan, 2009; Thirumaran et al., 2009; Erulan et al., 2009; Sangeetha and Thevenathan et al., 2009. Our present study was undertaken to study the fertilizing efficiency of liquid extracts of brown alga *Sargassum wightii* and green alga *Ulva lactuca* on cluster bean.

Materials and Methods

Preparation of liquid extracts of seaweeds:

The marine alga *S. wightii* and *Ulva lactuca* were collected from Mandapam (Lat 9° 45' N; Long 79° 15' E) located in South east coast of Tamil Nadu. The alga was brought to the laboratory and washed thoroughly in tap water for 3 or 4 times to remove all epiphytes, sand particles and associated fauna. The wet weight of sample of collected algal samples was taken, shade dried and then the sample dry weight was determined. Boiled extract was prepared from the algal powder as per the methods suggested by Bhosle et al., (1975). Different concentrations (0.5%, 1.0%, 1.5%, 2.0%, 2.5% and 5.0%) of *S. wightii* and *U. lactuca* was

* Corresponding Author, *Email*: vijayapsac@gmail.com, Tel:+919894289088

prepared by mixing appropriate level of extracts with distilled water.

Preparation of pot study

Seeds of cluster bean were purchased from Agriculture College and Research Institute, Madurai. They were surface sterilized with 0.1% mercuric chloride and then sown in earthenware pots (9 cm dia) filled with sterilized standard soil mix supplemented with sufficient quantity of NPK. The seed-to-seed distance in pot was maintained as 3-5 cm and pots were maintained regularly. After 10 days, potted plants were soil drenched with different concentrations of SLE. About 50 ml of different concentrations of extracts was given at interval of 3 days. Growth parameters viz., shoot length, root length, total height, total fresh and dry weight, leaf area and moisture content were determined. Photosynthetic pigments (Arnon, 1949), protein content (Lowry et al., 1951), reducing sugar (Nelson, 1944), ascorbic acid (Roe,1954) and nitrate reductase activity (Jaworski et al., 1971) were assessed in the leaves of treated plants. Similarly, yield parameters such as clusters/plant, flowers/clusters, number of pods/plant, length and pod weight was also observed Growth and biochemical parameters were recorded in 4 weeks old treated and control plants. After 60 days, yield characters were observed. All pot experiments were done in four replicates each under natural uniform conditions.

Physico-chemical and hormone analysis of seaweed extracts of *Sargassum wightii* and *Ulva lactuca*

The physical observations such as colour and pH and elements such as copper, manganese, iron, zinc, cobalt, potassium, magnesium and sodium were estimated using Atomic Absorption Spectrophotometer (Humpshires**,** 1956). Further, liquid extracts of both seaweeds were subjected for estimation of auxin (Gordon and Paleg, 1957), gibberellin (Graham and Henderson, 1961) and cytokinin (Syono and Torrey, 1976) (Table 1).

Table 1: Physio-chemical and hormone analysis of *Sargassum wightii* and *Ulva lactuca* extracts

	Sargassum wightii	*Ulva lactuca*
General parameters		
Colour	Brown	Green
pH	6.3	5.2
Chemical parameters		
Copper	3.016	2.876
Manganese	0.053	0.050
Zinc	1.583	1.020
Iron	0.500	0.417
Potassium	1.070	0.980
Magnesium	17.13	9.280
Cobalt	0.103	0.201
Sodium	5.775	5.04
Growth hormones		
Auxin	3.5	2.98
Cytokinin	9	6.0
Gibberellin	5.5	4.2

All the parameters given are in mg/L except colour and pH.

Results and Discussions

In our results, use of liquid extracts of our experiment algae generally increased the rate of growth and physiology of cluster bean. There was a appreciable increase in growth, biochemical and yield characters when 1.5% of *Sargassum wightii* and 1.0% of *Ulva lactuca* was applied to Cy*amopsis tetragonoloba.* Higher concentrations of both the algae were found to show retarding effect on all the above tested parameters (Table 2 and 3).

Growth parameters such as shoot length, root length, total fresh and dry weight, leaf area and moisture content and relative water content were increased when 1.5% of *Sargassum wightii* and 1.0% of *Ulva lactuca* extracts was applied. Further, retarding effect was observed in growth parameters when the plants were treated with higher concentration (above 1.5% in case of *Sargassum wightii* and 1.0% of *Ulva lactuca*). Our results corroborated with the previous studies on various plants (Sobithabai et al., 2007;

Xavier and Jesudass, 2007; Ramamoorthy et al., 2007; Zodape, 2008; Jothinayagi and Anbazhagan, 2009; Thirumaran et al., 2009; Erulan et al., 2009; Sangeetha and Thevenathan et al., 2009).

Further, lower concentrations was found to be effective in *Abelmoschus esculentus* (Asir selin kumar et al., 2007), *Pennisetum typhoides* (Balakrishnan et al., 2007), *Vigna mungo* (Ramamoorthy et al., 2007), *Cajanus cajan* (Ramamoorthy and Sujatha, 2007), Cumbu (Murugalakshmi kumari et al., 2002), Cluster bean (Thirumal thangam et al., 2003). Similarily, Arumugam et al., (2008) reported that lower concentration of *Sargasssum wightii* (1%) increased the shoot and root length, fresh weight of shoot and root, lateral roots and leaf area. Moreover, Lingakumar et al., (2004) reported that *Sargasum wightii* at 1% concentration showed best response on growth parameters in *Zea mays* whereas in *Phaseolus mungo* it was 0.5% concentration.

On the contrary, Sivasankari et al., (2006b) reported that lower concentrations of *S. wightii* (20%) enhanced growth characters such as shoot and root length and fresh weight and dry weight of *Vigna sinensis*. Similarly, 20% of *Rosenvigea intricata* enhanced the growth, yield and chlorophyll content pigment in *Abelmoschus esculentus* (Thirumaran et al. 2009). The growth enhancing potential of seaweed might be attributed to the presence of carbohydrate (Booth, 1965), Phenyl acetic acid (Taylor and Wilkinson, 1997), micro and macro elements (Challen and Hemingway, 1965).

Table 2: Influence of liquid extracts of *Stoechospermum marginatum* on growth characteristics of cluster bean.

Seaweed extract Treatments	Shoot length (cm)	Root length (cm)	Total height (cm)	Total fresh wt (mg)	Total dry wt (mg)	Leaf Area (mm^2)	Moisture content (%)
Control	8.725 **b**	12.250 **a**	20.00 **ab**	1.015 **a**	0.400 **a**	42.115 **b**	41.533 **a**
0.5%	9.325 **b**	13.050 **ab**	21.400 **bc**	1.130 **bc**	0.492 **b**	44.183 **b**	54.685 bc
1.0%	10.000 **c**	3.400 **bc**	23.33 **bc**	1.620 **de**	0.620 **c**	50.790 **c**	63.645 **bc**
1.5%	11.400 **cd**	15.250 **d**	26.65 **bc**	2.595 **f**	0.962 **d**	68.165 **d**	64.825 **c**
2.0%	0.300 **c**	14.450 **cd**	24.750 **c**	1.800 **e**	0.605 **c**	58.400 **d**	64.808 **c**
2.5%	8.950 **b**	14.200 **cd**	23.150 **bc**	1.365 **cd**	0.515 **b**	43.425 **b**	53.720 **b**
5.0%	6.425 **a**	12.300 **a**	18.725 **a**	0.915 **ab**	0.400 **a**	35.450 **a**	55.785 **bc**

Table 3: Influence of liquid extract of *Ulva lactuca* on growth characteristics of cluster bean

Seaweed extract treatments	Shoot length (cm)	Root length (cm)	Total height (cm)	Total fresh wt (mg)	Total dry wt (mg)	Leaf Area (mm^2)	Moisture content (%)
Control	9.100 **ab**	13.725 **b**	22.075 a**b**	1.087 **ab**	0.452 **a**	36.947 **a**	59.040 **a**
0.5%	8.800 **ab**	14.85 **b**	24.225 **bc**	1.125 **ab**	0.465 **ab**	53.462 **b**	64.550 **ab**
1.0%	10.250 **b**	15.23 **b**	25.450 **c**	2.595 **c**	0.750 **c**	56.637 **b**	59.565 **b**
1.5%	8.800 **ab**	14.900 **b**	23.675 **bc**	1.562 **b**	0.805 **c**	56.475 **b**	51.342 **a**
2.0%	8.725 **ab**	14.000 **b**	22.625 **bc**	1.125 **ab**	0.600 **b**	52.100 **b**	38.100 **a**
2.5%	8.200 **a**	13.325 **b**	21.775 **ab**	0.812 **a**	0.575 **b**	39.137 **a**	36.727 **a**
5.0%	7.750 **a**	10.875 **a**	19.275 **a**	0.705 **a**	0.400 **a**	36.667 **a**	31.447 **a**

Means sharing within the rows are significantly different ($P \leq 0.05$ level).
Different letters followed in each row statistically significant based on DMRT

The observations made on the potted plants applied with seaweed liquid extracts of *S.wightii* and *Ulva lactuca* showed a better increment in the biochemical parameters also. Lower concentrations of *S.wightii* (1.5%) and *Ulva lactuca* (1.0%) were found to be potential concentration in enhancing the photosynthetic pigments, protein, sugars, amino acid, ascorbic acid nitrate reductase activity (Table 4 and 5). The increase in photosynthetic pigments may be due to the presence of betaines (Blunden et al., 1997), increase in number and size of the chloroplast and better grana development (Atzmon and Van Staden, 1994). Our results were in agreement with previous studies of Kumar et al., (1993), Anantharaj and Venkatesalu (2001) in related to carbohydrate, protein and lipid content. Further, in cluster bean 1.0% concentration of *Caulerpa scalpelliformis* and *Gracillaria corticata* enhanced the biochemical parameters such as chlorophyll-a, chlorophyll-b, xanthophylls, carotenes, total carbohydrate, total protein and lipid. On contrary, liquid fertilizer extracted from brown alga *Sargassum wightii* at 10% concentration increased the content of chlorophyll-a, chlorophyll-b, total chlorophyll, protein and total sugars in *Vigna radiata* (Sivasankari et al., 2006a). *Caulerpa scalpelliformis* (0.5%) and *Padina pavonica* (0.5%) increased the photosynthetic pigments in cluster bean (Thirumal thangam et al., 2006). Increase in the photosynthetic pigments of cluster bean may be due to the presence of magnesium which is the chief constituent for chlorophyll synthesis (Table 1).

Table 4: Influence of liquid extracts of *Sargassum wightii* on biochemical characteristics of cluster bean

Seaweed extract treatments	Chl-a (mg./g/fr.wt)	Chl-b (mg./g/fr.wt)	Total chlorophyll (mg./g/fr.wt)	Protein (mg./g/fr.wt)	Reducing sugar (mg./g/fr.wt)	Ascorbic acid (mg./g/fr.wt)	NRA (µ moles No-2/gm.fr.wt/hr)
Con	0.5225 a	0.4200 a	0.9425 a	19.200 b	41.650 a	0.568 a	0.820 a
0.5%	0.6500 a	0.4450 b	1.095 a	24.550 b	55.850 b	0.656 ab	1.090 b
1.0%	0.6650 ab	0.515 c	1.180 c	28.250 c	62.650 c	0.700 c	1.635 d
1.5%	0.975 d	0.710 d	1.685 d	33.30 d	84.10 d	0.775 bc	2.125 e
2.0%	0.805 c	0.530 b	1.335 b	26.625 bc	66.80 c	0.637 ab	1.725 d
2.5%	0.650 c	0.442 b	1.092 a	21.350 a	51.50 b	0.593 a	1.345 c
5.0%	0.590 b	0.315 a	0.905 a	19.90 a	39.10 a	0.562 a	0.970 ab

Table 5: Influence of liquid extracts of *Ulva lactuca* on biochemical characteristics of cluster bean.

Seaweed extract treatments	Chl-a (mg./g/fr.wt)	Chl-b (mg./g/fr.wt)	Total chl. (mg./g/fr.wt	Protein (mg./g/fr.wt)	Reducing sugar (mg./g/fr.wt))	Ascorbic acid (mg./g/fr.wt)	NRA (µ moles NO-2g-1.fr.wt/hr)
Control	0.6125 bc	0.4850 a	1.097 bc	18.750 ab	44.300 a	0.3800 a	0.900 a
0.5%	0.7400 cd	0.522bc	1.262 e	26.350 c	52.100 b	0.4550 ab	1.172 bc
1.0%	0.8625 d	0.645d	1.5072 f	36.825 d	71.025 c	0.5750 c	1.972 e
1.5%	0.5970 bc	0.495 c	1.170de	23.525 bc	53.350 d	0.5050 bc	1.485 d
2.0%	0.6150 bc	0.456 c	1.052 cd	18.900 ab	53.250 c	0.4500 ab	1.345 cd
2.5%	0.5550 ab	0.392 ab	0.942 ab	16.425 a	48.150 b	0.3900 a	1.237 cd
5.0%	0.4325 a	0.322 a	0.754 a	13.925 a	\35.100 a	0.3625 a	0.922 ab

Means sharing within the rows are significantly different (P ≤ 0.05 level).
Different letters followed in each row statistically significant based on DMRT

Similarily, EL-Sheekh and EL-Saied (1999) have also reported that presence of magnesium in seaweed extracts was found to be induce growth in *Vicia faba*. Moreover, Subramanian and Kannathasan (1987) also suggested that the seaweed liquid fertilizer prepared from brown alga *Sargassum wightii* may yield promising results than the green algae and also suggested that presences of phycocolloids in brown alga would be responsible for inducing plant growth.

The cluster bean plants treated with seaweed liquid extract of *S.wightii* and *Ulva lactuca* showed differential responses in the yield characters also. There was noticeable increase in cluster/plants, flowers/cluster, number of pods/plant, pod length, pod weight and number of seeds per pod when 1.5% of *S.wightii* and 1.0% of *Ulva lactuca* were given as soil drench (Table 6 and 7). Further, Sethi and Adhikary (2008) have reported that 1% foliar spray enhanced the yield parameters such as fruit length and fruit weight of certain vegetable crops. Similar findings were observed in black gram in which pod length, pod weight, seed weight per pod were found to be increased when lower concentrations of seaweed liquid fertilizer were applied. Further, Thirumaran et al., (2009) reported that 20% seaweed extract of *Rosenvigea intricata* increased the length and weight of vegetables in *Cyamopsis tetragonoloba.* Further, liquid extracts of seaweeds increased the yield in bean (Temple and Bomke, 1989), Canola (Ferreira and Lourens, 2002) cucumber (Abetz, 1980). Similarly, crude seaweed liquid fertilizer on ber fruits (*Zizyphus mauritiana)* yielded significant promotional effect in terms of length, breadth and weight of the fruit (Rama Rao, 1992). Subramanian and Kannathasan (1987) reported that presence of hormones like growth promoting substances are more in brown and red algae than green algae.

Table 6: Influence of liquid extracts of *Sargassum wightii* on yield parameters of cluster bean.

Seaweed treatments	Number of clusters/plant	Number of flowers/cluster	Number of Pods/plant	Pod length (cm)	Pod weight (g)
Control	4.000 **bc**	4.000 **bc**	2.250 **a**	6.250 **bc**	3.075 **ab**
0.5%	4.750 **cd**	5.000 **cd**	2.500 **ab**	6.750 **cd**	3.350 **ab**
1.0%	5.500 **de**	6.500 **de**	3.250 **bc**	8.250 **e**	3.750 **bc**
1.5%	6.250 **e**	7.750 **e**	3.500 **c**	8.750 **de**	4.725 **c**
2.0%	5.000 **cd**	4.750 **cd**	2.500 **ab**	6.750 **cd**	4.125 **bc**
2.5%	3.500 **b**	3.500 **ab**	2.500 **ab**	5.500 **b**	3.500 **ab**
5.0%	2.500 **a**	3.000 **a**	1.750 **a**	3.750 **a**	2.600 **a**

Means sharing within the rows are significantly different ($P \leq 0.05$ level).
Different letters followed in each row statistically significant based on DMRT

Table 7: Influence of liquid extracts *Ulva lactuca* on yield characteristics of cluster bean.

	Number of clusters/plant	Number of flower/cluster	Number of Pods/plant	Pod length (cm)	Pod weight (g)	Number of seeds/pod
Control	5.250 **ab**	4.250 **a**	5.362 **a**	6.187 **bc**	3.375 **ab**	5.500 **b**
0.5%	6.000 **bcd**	4.875 **a**	5.925 **b**	7.375 **cd**	3.937 **abc**	5.750 **bc**
1.0%	7.250 **e**	6.000 **ab**	5.525 **c**	8.562 **d**	5.437 **d**	7.000 **c**
1.5%	6.500 **cde**	5.000 **b**	5.250 **ab**	7.375 **cd**	4.562 **d**	6.500 **bc**
2.0%	6.750 **de**	5.175 **ab**	4.350 **b**	6.437 **c**	3.687 **abc**	6.500 **bc**
2.5%	5.500 **abc**	4.675 **a**	4.125 **b**	5.000 **ab**	3.312 **ab**	5.250 **b**
5.0%	4.750 **a**	4.300 **a**	3.000 **a**	4.250 **a**	2.750 **a**	3.750 **a**

Means sharing within the rows are significantly different (P ≤ 0.05 level).
Different letters followed in each row statistically significant based on DMRT

Conclusions

Our results evidences that enhancement of growth, biochemical and yield parameters might be due to differential level of micro and macro elements, growth hormones, trace elements, vitamins etc, in the liquid extracts of both algae (Table 1). Growth hormones especially cytokinin present in seaweed extract would have rendered increase in growth of cluster bean. In our study, cytokinin content was higher in brown algae than the green one. We can also conclude that brown alga which contains more amount of hormones, nutrients, vitamins etc., than other seaweeds could be effective in enhancing the growth and physiology of certain plants. Liquid seaweed extract can be used as substitute for chemical fertilizers in order to avoid soil pollution. Further, the study also emphasizes that the use of LE of seaweeds can be effectively used as eco-friendly approach to organic farming.

Acknowledgement

We wish to express our sincere thanks to Director, Centre for Advanced Studies in Botany, Madras University for giving us valuable suggestion and useful suggestions. Further thanks are extended to Central Electro Chemical research Institute, Karaikudi for chemical analysis of our samples.

References

Abetz, P. (1980). Seaweed extracts: Have they a place in Australian agriculture or horticulture? Journal of the Australian Institute of Agricultural Science 46, 23-29.

Anantharaj, M. and Venkatesalu V. (2001). Effect of seaweed liquid fertilizer on *Vigna catajung*. Seaweed Res. Utiln. 23, 33-39.

Arnon D.I. (1949). Copper enzymes in isolated chloroplasts, Polyphenol oxidase in *Beta vulgaris*. Plant Physiol. 24, 1-15.

Arumugam, R., Anantharaman, P., Thirumaran, G., and Balasubramanian, T. (2008). Effect of seaweed extract from *Sargassum wightii* on *Vigna unguiculata* (L.) Walp. var. Pusa 151. Seaweed Res. Utiln., 30 (special issue), 233-239.

Asir Selin kumar, R., Sobithabai, R., and Premalatha Y. (2007). A comparative study on the effect of seagrass and seaweed liquid fertilizer oxidizing enzymes in *Zea mays* during senescence. Seaweed Res. Utiln. 29, 105-109.

Balakrishnan, C.P., Kumar, V., and Mohan, V. (2007). Studies on effect of crude seaweed extract on seedling growth, biochemical parameters in *Pennisetum typhoides*. Seaweed Res. Utiln. 29, 89-96.

Bhosle, N.B., Untawale, A.G., and Dhargalkar V.K. (1975). Effect of seaweed extract on the growth of *Phaseolus vulgaris* L. Indian J. Mar. Sci. 4, 207-210.

Blunden, G., Jenkins, T., and Wan L.Y. (1997). Enhanced leaf chlorophyll levels in plants treated with seaweed extracts. J. Appl. Phycol. 8(6), 535-543.

Booth, E. (1965). Manurial value of seaweeds. Bot.Mar. 8, 138-143.

Challen, S.B., and Hemingway, J.C. (1965). Growth of higher plants in response to feeding with seaweed extracts. Proc. of the V Int. Seaweed Symp. Halifax. August 25-28.

Chapman, V.J., and Chapman, D.J. (1970). Seaweeds and their uses. 3rd edition. Chapman and Hall, USA, pp 334.

Crouch, I.J., and Vanstaden, J. (1993). Evidence for the presence of plant growth regulators in commercial seaweed products. Plant Growth. Reg. 13, 21-29.

El-Sheekh, M.M., and El-Saied, A.E.F. (1999). Effect of seaweed extracts on seed germination, seedling growth and some metabolic process of Fabe beans (*Vicia faba* L.). Phykos. 38, 55-64.

Erulan, V., Soundrapandian, P., Thirumaran, G., and Ananthan, G. (2009). Studies on the effect of *Sargassum polycystum* (C.agardh, 1824) extract on the growth and biochemical composition of *Cajanus Cajan (*L.) Mill sp . American-Eurasian Journal of Agriculture & Environmental Science 6, 392-399.

Featonby-Smith, B.C., and Van Staden, J. (1983). The effect of seaweed concentrate and fertilizer on the growth of *Beta vulgaris*. Zeitsschrift fur Pflanzenphysiologie. 112: 155-162.

Featonby-Smith, B.C., and Van Staden, J. (1987). Effects of seaweed concentrate on grain yield in barley. S. Afr. J. Bot. 52:125-128.

Ferreira, M.I., and Lourens, A.F. (2002). The efficacy of liquid seaweed extract on the yield of Canola plants. S.Afr.J.Plant Soil. 198: 159-161.

Gordon, S.A., and Paleg, L.G. (1957). Quantitative measurement of indole acetic acid. Physiol. Plant. 10: 37-48.

Graham, H.D., and Henderson, J.H.M. (1961). Reaction of gibberellic acid and gibberellins with Folin-Wu Phosphomolybdic acid reagent and its use for quantitative asay. Plant Physiol. 36: 405-408.

Humpshires, E.C. (1956). Mineral components and ash analysis. In: Modern methods of Plant analysis. Ed. Rach K and M.V Tracer. Springer-Valeg. Berlin.

Jameson, P.E. (1993). Plant hormones in the algae. Prog. Phycol Res. 9, 239–279.

Jaworski, E.G. (1971). Nitrate reductase in intact plant tissue. Biochem. Biophys. Res. Commun. 43 : 1274-1279.

Jothinayagi, N., and Anbazhagan, C. (2009). Effect of seaweed liquid fertilizer of S*argassum wightii* on the growth and biochemical characteristics of *Abelmoschus esculentus* (L.) Medikus. Recent Research in Science and Technology 1: 155–158

Kumar, V., Mohan, V.R., Murugeswari, R., and Muthusamy, M. (1993). Effect of crude and commercial seaweed extracts on seed germination and seedling growth in green gram and black gram. Seaweed. Res. Utiln. 16 (1&2), 23-27.

Lingakumar, K., Jeyaprakash, R., Manimuthu, C., and Haribaskar, A. (2004). Influence of *Sargassum* sp. crude extract on vegetative growth and biochemical characteristics in *Zea mays* and *Phaseolus mungo.* Seaweed. Res. Utiln. 26 (1&2), 155-160.

Lowry, O.H., Rosebrough, N.J., Farr, A.L., and Randall, R.J. (1951). Protein measurement by folin-phenol reagent. J.Biol. Chem. 193, 265-275.

Murugalakshmi kumari, R., Ramasubramanian, V., and Muthuchezhian, K. (2002). Studies on the utilization of seaweed on the utilization of seaweed as an organic fertilizer on the growth and some biochemical characteristics black gram and cumbu. Seaweed Res. Utiln. 24 (1): 125-128.

Nelson, N. (1944). A photometric adaptation of Somogyis method for the determination of reducing sugar. Anal. Chem. 31: 426-428.

Ramamoorthy, K., and Sujatha K. (2007). Aqueous seaweed sprays on the growth and yield of Pigeon Pea (*Cajanus cajan)* Seaweed Res and Utiln. 29: 111-117.

Ramamoorthy, K., and Sujatha, K. (2007). Effect of seaweed extracts on the ageing of blackgram seeds. Seaweed Res and Utiln. 29: 119-123.

Ramamoorthy, K., Sujatha, K., and Sivasubramanium, K. (2007). Utilization of seaweed extracts for enhancing yield in black gram (*Vigna mungo (*L.) hepper. Seaweed Res and Utiln. 29: 97-100.

RamaRao, K. (1992). Seaweed as biofertilizer in Indian horticulture. Seaweed Res. Utiln 14: 99-101.

Roe, J.H., 1954. Chemical determination of ascorbic, dehydroascorbic and diketogluconic acids. Meth. Biochem Anal., 1: 115-139.

Sangeetha, V., and Thevanathan R. (2010). Biofertilizer Potential of Traditional and Panchagavya Amended with Seaweed Extract. The Journal of American Science 6: 61-67

Sethi, S.K., and Adhikary, S.P. (2008). Effect of Seaweed liquid fertilizer (SLF) on vegetative growth and yield of black gram, brinjal and tomato. Seaweed Res.Utiln. 30 (special issue), 241-248.

Sivasankari, S., Chandrasekaran, M., Kannathasan, K., and Venkatesalu, V. (2006a). Studies on the biochemical constituents of *Vigna radiata* Linn.

treated with seaweed liquid fertilizer. Seaweed Res. Utiln. 28 (1). 151-158.

Sivasankari, S., Venkatesalu, V., Anantharaj, M., and Chandrasekaran, M. (2006b). Effect of seaweed liquid extract on the growth and biochemical constituents of *Vigna sinensis.* Bioresource Technology 97: 1745-1751.

Sobithaibai, I., Irene wilsey, I., Effie, A., and Asir selin kumar, R. (2007). Impact of *Spyridia hypenoides* and *Syringodium isoedifolium* extracts on the pigmentation in *Abelmoschus esculenthus.* Seaweed Res. Utiln. 29: 75-79.

Subramanian, S.K., and Kannathasan, V. (1987). Studies on the effect of seaweed liquid fertilizers. Int. Symp. Phycol. University of Madras. Abst. Vol.33.

Syono, K., and Torrey, J.G. (1976). Identification of cytokinins of root nodules of the Garden Pea, *Pisum sativum* L. Plant physiol. 57, 602-606.

Taylor, I.E.P., and Wilkinson, A.J. (1977). The occurrence of gibberellins and gibberellins like substances in algae. Phycologia. 16, 37-42.

Temple, W.D., and Bomke, A.A. (1989). Effect of kelp (*Macrocystis integrifolia* and *Ecklonia maxima*) foliar application of bean crop growth. Plant and Soil. 117(1): 85-92.

Thirumal thangam, R., and Marial Victorial rani S. (2006). Effect of seaweed liquid fertilizers on photosynthetic pigments of *Sorghum bicolor* (L.) Moench. Seaweed Res. Utiln. 28: 81-84.

Thirumal thangam, R., Maria Victorialrani, S., and Peter marian, M. (2003). Effect of seaweed liquid fertilizers on the growth and biochemical constituents of *Cyamopsis tetragonolaba* (L.) Taub. Seaweed Res. Utiln. 25:99-103.

Thirumaran,G., Arumugam, M., Arumugam, R., and Anantharaman, P. (2009). Effect of Seaweed Liquid Fertilizer on Growth and Pigment Concentration of *Cyamopsis tetrogonolaba* (L.) Taub. American-Eurasian Journal of Agronomy 2: 50-56

Wallen Kemp, J.O. (1955). Treasure from the sea. Organic Gard. F. 2(3), 52–53.

Xavier, S.A., and Louis Jesudass, L. (2007). Effect of seaweed extract on cluster beans. Seaweed Res and Utiln. 29, 85-87.

Zhang, X., and Ervin, H. (2004). Seaweed extract and humic acid contain cytokinins. Crop. Sci. 44 (5), 1509.

Zodape, S.T., Mukherjee S., Reddy, M.P., and Chaudharya, D.R. (2009). Effect of *Kappaphycus alvarezii* (Doty) Doty ex silva. extract on grain quality, yield and some yield components of wheat (*Triticum aestivum* L.) International Journal of Plant Production 3, 97-101.